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Effect of Throttle Body Bore Diameter on Torque and Power Output of a 150 cc Fuel-Injected Motorcycle Engine: An Experimental Chassis-Dynamometer Study

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A R T I C L E I N F O

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A B S T R A C T

This study examines the effect of throttle body bore-diameter variation on the power and torque output of a Honda Vario 150 cc motorcycle under factory-standard engine and Electronic Control Unit (ECU) conditions. A quantitative experimental design was employed, in which three throttle body diameters – 26 mm (standard), 28 mm, and 30 mm – were each tested three times on a chassis dynamometer across an engine-speed range of 6,000–9,000 rpm. Peak power and torque values were analysed using one-way Analysis of Variance (ANOVA) with Tukey HSD post-hoc comparison. The 30 mm throttle body produced the highest mean peak power (11.32 HP), while the 26 mm standard throttle body produced the highest mean peak torque (11.12 Nm) with the smallest standard deviation, indicating the most repeatable performance. However, ANOVA results showed that throttle body diameter had no statistically significant effect on either power ($F(2,6) = 4.731$, $p = 0.058$) or torque ($F(2,6) = 2.489$, $p = 0.163$) at $\alpha = 0.05$, although the associated effect sizes ($\eta^2 = 0.612$ and 0.453, respectively) were large. The 30 mm throttle body tended to sustain higher power at elevated engine speeds (7,500–8,500 rpm), whereas the 26 mm unit delivered the most consistent torque in the mid-range. These findings indicate that enlarging the throttle body alone, without a corresponding recalibration of the ECU fuel map, does not translate into a statistically reliable performance gain, and that any bore enlargement should be accompanied by engine-management adjustment to fully exploit the additional airflow

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INTRODUCTION

The motorcycle remains the most widely used mode of personal transportation in Indonesia because of its high mobility, low operating cost, and practicality across varied road conditions. Manufacturers continue to pursue improvements in fuel efficiency, engine performance, and emission control through Electronic Fuel Injection (EFI) systems, in which fuel delivery is governed electronically by an Electronic Control Unit (ECU) that processes signals from multiple sensors, yielding more precise combustion than carburettor-based systems (Almeyda & Firdaus, 2024).

A key element of the EFI system is the throttle body, the component that regulates the volume of air entering the combustion chamber through the throttle valve opening. The amount of air admitted determines how much fuel the ECU injects, thereby governing the quality of combustion. When intake airflow matches engine requirements, combustion proceeds efficiently and produces optimal power and torque; when it does not, engine performance can deteriorate. Consequently, the throttle body is one of the most frequently modified components among riders seeking performance gains.

The Honda Vario 150 cc is a widely used automatic scooter equipped with Programmed Fuel Injection (PGM-FI) technology and full ECU control of the injection system. Despite its favourable fuel economy and adequate day-to-day performance, many owners still modify the intake system—most commonly by replacing the throttle body—in the hope of improving acceleration, power, and torque. Enlarging the throttle body is presumed to increase the volume of air reaching the combustion chamber and thereby raise output; however, a larger bore does not automatically translate into higher power or torque unless it is matched to engine characteristics and fuel-injection calibration.

Prior studies confirm that intake-system modification affects engine performance, although the direction and magnitude of the effect are highly dependent on engine type and ECU configuration. Lapisa et al. (2022) reported that throttle body diameter variation changed power, torque, and exhaust emissions on a Honda Beat PGM-FI 110 cc, with an intermediate 24 mm bore outperforming both smaller and larger diameters. Maulana et al. (2023) showed that a combination of throttle body and ECU variation influenced torque and power on the Honda Vario 150 PGM-FI, underscoring that throttle-body behaviour cannot be separated from the injection-control strategy in use. Kamaludin (2026) further indicated that pairing throttle body diameter variation with ECU changes altered power, torque, air-fuel ratio (AFR), mean effective pressure (MEP), and brake mean effective pressure (BMEP) on a Yamaha WR155R, confirming that diameter modification affects performance in a manner strongly dependent on engine characteristics and fuel-management settings.

Additional evidence comes from Faerus and Pohan (2022), who found that altering the intake air-velocity path on a 155 cc engine changed power and torque characteristics, and from Almeyda and Firdaus (2024), who showed that shortening the velocity stack improved power by facilitating smoother airflow toward the combustion chamber. Collectively, these findings demonstrate that airflow characteristics within the intake system are strongly linked to engine performance.

Nevertheless, most previous work has been conducted on different motorcycle models, has used racing ECUs, or has combined several modification variables simultaneously (ECU, velocity stack, and throttle body together). Research that isolates the effect of throttle body diameter on power and torque for the Honda Vario 150 cc under fully standard engine and ECU conditions remains limited—a research gap this study addresses by evaluating 26 mm, 28 mm, and 30 mm throttle bodies on a standard-ECU Vario 150 cc using chassis dynamometer (dynotest) testing. The findings are intended to provide empirical guidance for academics, automotive practitioners, and riders considering intake modifications consistent with the engine's original characteristics.

LITERATURE REVIEW

Internal Combustion Engine and Fuel Delivery System

An internal combustion engine converts the chemical energy of fuel into mechanical energy through in-cylinder combustion, producing gas pressure that drives the piston and rotates the crankshaft (Kamaludin, 2026). A four-stroke gasoline engine completes intake, compression, power, and exhaust strokes in sequence, and its performance depends on air–fuel mixture quality, volumetric efficiency, ignition timing, compression ratio, and the smoothness of intake airflow (Kamaludin, 2026). Electronic Fuel Injection (EFI), governed by the ECU, has largely replaced carburation because it meters fuel more precisely, improving throttle response, fuel economy, and emissions (Almeyda & Firdaus, 2024). Azhar (2023) demonstrated empirically that converting from carburettor to injection increased power by 4.52% and torque by 2.21%, while Hifni et al. (2025) found that an injection system produced higher maximum power (27.3 HP) and torque (27.40 Nm) than an equivalent carburettor configuration on a 250 cc sport motorcycle.

Throttle Body and the Air-Intake Path

The throttle body regulates the volume of air entering the intake manifold according to throttle-valve opening, which is sensed by the Throttle Position Sensor (TPS) and reported to the ECU so that injector pulse width can be adjusted accordingly (Almeyda & Firdaus, 2024). Its principal sub-components include the throttle valve, a bypass passage for idle circulation, the TPS, an idle air control valve, and the main air-flow bore whose diameter is the independent variable examined in this study. The throttle body operates as part of an integrated intake path that also includes the air filter and the velocity stack; restrictions or geometry changes anywhere along this path alter volumetric efficiency, torque, and power (Faerus & Pohan, 2022; Almeyda & Firdaus, 2024). Consequently, enlarging the throttle body alone does not guarantee a performance gain if upstream or downstream components cannot supply or exploit the additional airflow.

From the continuity equation, $Q = A \times v$, cross-sectional area increases quadratically with radius ($A = \pi r^2$), so a larger bore substantially increases the potential air volumetric flow rate (Laksono, 2025). However, an oversized bore relative to engine displacement can reduce air velocity at low-to-moderate engine speeds, impairing cylinder filling in that range even as it raises the flow ceiling at high engine speed (Laksono, 2025). Lapisa et al. (2022) demonstrated this trade-off directly: a 24 mm bore outperformed both a smaller 22 mm and a larger 26 mm throttle body on a 110 cc engine, confirming the existence of an engine-specific optimal diameter rather than a monotonic "bigger-is-better" relationship.

Volumetric Efficiency and Air-Fuel Ratio

Volumetric efficiency (η_v) expresses how effectively a cylinder is filled with air during the intake stroke relative to its theoretical displacement, $\eta_v = m_a / (\rho_a \times V_d) \times 100\%$, and is influenced by atmospheric pressure, intake air temperature, engine speed, valve timing, manifold geometry, throttle body diameter, and air-filter restriction (Almeyda & Firdaus, 2024). Standard engines typically operate at 75–90% volumetric efficiency, whereas high-performance configurations may exceed 100% through ram-effect resonance. The air-fuel ratio (AFR), the mass ratio of air to fuel, is stoichiometric near 14.7:1 for gasoline; rich mixtures (AFR below 14.7) favour maximum power output, while lean mixtures (AFR above 14.7) improve economy but, if excessive, can cause misfire and reduce torque and power (Maulana et al., 2023; Azhar, 2023). Enlarging the throttle body increases intake air without a corresponding fuel-map change, tending to lean the mixture unless the ECU can compensate within its programmed range.

Electronic Control Unit (ECU)

The ECU processes data from the TPS, Manifold Absolute Pressure (MAP) sensor, Intake Air Temperature (IAT) sensor, Engine Coolant Temperature (ECT) sensor, Crankshaft Position (CKP) sensor, and oxygen sensor to determine injector pulse width and ignition timing, maintaining AFR near the target value through closed-loop feedback (Maulana et al., 2023; Azhar, 2023). A factory ECU's compensation range is bounded by its pre-programmed fuel map; once intake air volume exceeds that range—as can occur with an enlarged throttle body—the mixture becomes lean and performance can suffer (Maulana et al., 2023). Fauzil et al. (2023) showed that a racing ECU paired with a standard injector produced the best performance on a Jupiter MX King 150, underscoring that ECU calibration, not bore size alone, is often the limiting factor in exploiting a larger throttle body.

Dynamometer Testing

A dynamometer measures engine torque, power, and rotational speed by imposing a controlled load on the drivetrain. A chassis dynamometer, in which the drive wheel rests on a roller, is the most common configuration for motorcycle testing because it does not require engine removal and reflects real drivetrain losses (Almeyda & Firdaus, 2024). Power is derived from measured torque and engine speed via $P\ (kW) = 2\pi NT/60{,}000$, or, in horsepower, $HP = T \times RPM / 7127$ (Faerus & Pohan, 2022).

Honda Vario 150 cc Specification

The Honda Vario 150 cc uses PGM-FI with TPS, IAT, and ECT sensors integrated with the ECU to optimise injection timing and volume (Maulana et al., 2023). Its factory rating is 12.8 N·m of torque at 5,000 rpm and 12.64 PS of power at 8,500 rpm, figures below those of the Yamaha Aerox VVA (13.8 N·m; 14.95 PS), a performance gap that motivates many owners to pursue throttle-body modification.

Related Empirical Studies

A substantial body of recent work has examined intake-system and throttle-body modification on small-displacement, fuel-injected motorcycles. Sugiarto (2004) used CFD simulation to show that fuel-injection systems achieve favourable volumetric efficiency and homogeneous mixing, establishing intake-manifold design as a critical determinant of injection-system performance. Azhar (2023) compared injection against carburation with respect to compression ratio and reported measurable power and torque gains for injection. Lapisa et al. (2022) varied throttle body diameter (22, 24, 26 mm) on a Honda Beat 110 cc and found a non-monotonic performance response. Maulana et al. (2023) tested throttle body and ECU combinations on the Vario 150 and found that a 32 mm bore with a standard ECU increased power by 1–5% but reduced torque by 1.3–3.7% relative to the 26 mm standard unit. Prasetyo et al. (2023) reported that a 30 mm throttle body produced the highest power (11 HP) on a comparable 149 cc engine. Laksono (2025) tested 26, 28, and 32 mm racing throttle bodies specifically on the Vario 150 cc and found the largest bore produced the highest power and torque but at increased fuel consumption. Nindito et al. (2023) reported similar power and torque gains, with a fuel-economy penalty, when replacing the throttle body on a Honda CB150R. Fauzil et al. (2023) demonstrated that ECU calibration, more than injector or throttle hardware alone, determines realised performance gains. Hifni et al. (2025) confirmed the general superiority of injection over carburetion in both performance and efficiency on a 250 cc platform. Candra Putra et al. (2021) showed that torque rises faster than power at low-to-mid engine speed across 125 cc and 250 cc engines, a pattern relevant to interpreting where in the rev range a given throttle-body diameter provides its greatest benefit. Kamaludin (2026) and Faerus and Pohan (2022) both confirmed that intake-path modification interacts with ECU calibration to determine the net effect on AFR, MEP, BMEP, torque, and power. Together, these studies indicate that throttle body diameter is only one variable within a coupled intake–injection–combustion system, and that its effect on power and torque is contingent on cylinder displacement, ECU programming, and the capacity of upstream intake components—precisely the interaction this study investigates for the Honda Vario 150 cc under fully standard conditions.

Hypotheses

Consistent with the quantitative, experimental design of this study, the following hypotheses were formulated:

H1: Variation in throttle body bore diameter (26, 28, 30 mm) has a statistically significant effect on the peak power output of the standard Honda Vario 150 cc engine.

H2: Variation in throttle body bore diameter (26, 28, 30 mm) has a statistically significant effect on the peak torque output of the standard Honda Vario 150 cc engine.

METHODOLOGY

This study used a quantitative experimental design to determine the causal effect of throttle body bore diameter on the peak power and torque of a Honda Vario 150 cc engine.

Research Variables

The independent variable was throttle body diameter, tested at three levels: 26 mm (factory standard), 28 mm, and 30 mm. The dependent variables were peak engine torque (Nm) and peak engine power (HP), measured with a chassis dynamometer. Controlled variables included: vehicle specification (Honda Vario 150 cc with unmodified internal engine components); ECU (factory-standard, without remapping or a racing unit); fuel (Pertamax RON 92, identical quantity and quality across sessions); and testing conditions (identical dynamometer unit, calibration procedure, operator, and ambient conditions).

Location and Duration

Testing was conducted at JMS Servis Official, Jombang Regency, East Java, Indonesia, over approximately eight weeks, covering literature review, equipment preparation, vehicle and instrument calibration, dynamometer testing of the three throttle body configurations, data processing, and reporting.

Instruments and Materials

Table 1. Research Instruments

No.	Instrument	Function
1	Chassis dynamometer (dynotest)	Measures engine power and torque
2	Dynotest software	Records test results
3	Tachometer	Measures engine speed
4	Tool kit	Removal and installation of the throttle body
5	Laptop/computer	Data processing

Testing Procedure

(1) The standard 26 mm throttle body was installed and the engine warmed to normal operating temperature. (2) The motorcycle was secured on the chassis dynamometer roller. (3) A full-throttle pull was performed from low engine speed to the rev limiter, and power, torque, and engine speed were logged automatically at 500 rpm intervals across a 6,000–9,000 rpm window. (4) Each configuration was tested in three replications. (5) The throttle body was then replaced with the 28 mm unit and the procedure repeated, followed by the 30 mm unit. All tests were performed under identical mechanical and environmental conditions so that any performance difference could be attributed to throttle body diameter.

Data Analysis

Data were processed in Microsoft Excel and IBM SPSS Statistics. Descriptive statistics (mean, standard deviation) were computed for each configuration. Levene's test assessed the homogeneity-of-variance assumption prior to inferential testing. One-way ANOVA ($\alpha = 0.05$) was then used to test H1 and H2, followed by Tukey HSD post-hoc comparison where warranted.

RESULTS

Power and Torque across Engine Speed

Dynamometer testing was carried out from 6,000 to 9,000 rpm at 500 rpm intervals, with three replications per throttle body configuration. Readings at 6,000 rpm showed high variability, attributable to the transient start-up phase of the pull, so subsequent interpretation focuses on the controlled 6,500–8,500 rpm range. Table 2 and Table 3 summarise the mean power and torque recorded for each configuration at every engine speed.

Table 2. Mean Engine Power (HP) at Each Engine Speed (n = 3 per cell)

Engine Speed (rpm)	TB 26 mm	TB 28 mm	TB 30 mm
6,000	3.64	2.82	3.77
6,500	10.18	9.75	8.99
7,000	10.70	10.16	10.04
7,500	11.25	10.81	11.25
8,000	10.26	10.15	11.12
8,500	9.72	9.58	11.02
9,000	7.60	8.85	10.61

Table 3. Mean Engine Torque (Nm) at Each Engine Speed (n = 3 per cell)

Engine Speed (rpm)	TB 26 mm	TB 28 mm	TB 30 mm
6,000	4.27	3.28	4.40
6,500	11.12	10.35	9.82
7,000	10.85	10.30	10.17
7,500	10.65	10.23	10.64
8,000	9.10	9.00	9.87
8,500	8.12	8.00	9.20
9,000	5.98	6.98	8.37

Across the controlled range, power for all three configurations rose to a peak at 7,500 rpm before declining, whereas torque peaked earlier, at 6,500 rpm, consistent with the typical low-displacement gasoline-engine characteristic in which torque peaks before power. The 30 mm throttle body was distinctive in sustaining higher power from 8,000–8,500 rpm (11.12 and 11.02 HP) rather than declining as sharply as the 26 mm and 28 mm units, indicating a broader effective power band at the cost of a slightly later torque peak.

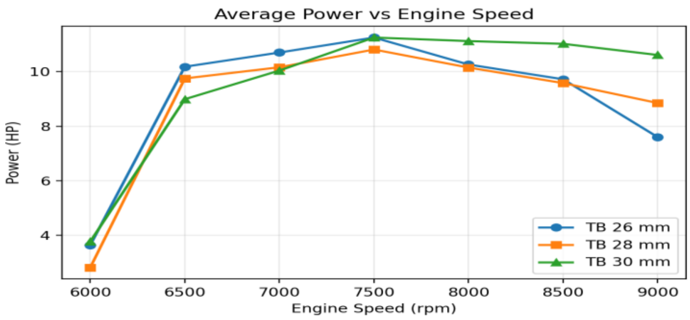

Figure 1. Mean Power versus Engine Speed for Three Throttle Body Diameters

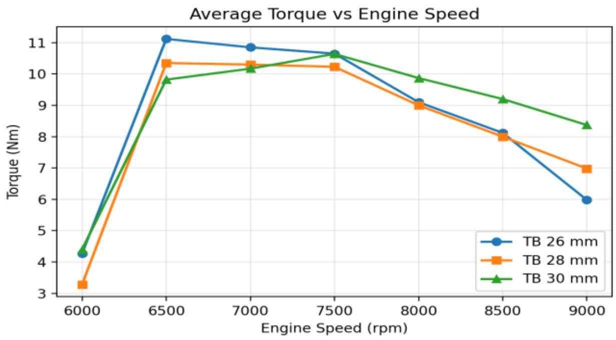

Figure 2. Mean Torque versus Engine Speed for Three Throttle Body Diameters

Peak Performance Recapitulation

Table 4. Recapitulation of Peak Power and Torque Values

TB	**Parameter**	**Trial 1**	**Trial 2**	**Trial 3**	**Mean**	**SD**	**Δ vs. 26 mm**
26 mm	Power (HP)	11.08	11.30	11.37	11.25	0.15	reference
28 mm	Power (HP)	10.73	10.80	10.90	10.81	0.09	−3.91%
30 mm	Power (HP)	11.54	11.50	10.93	11.32	0.34	+0.65%
26 mm	Torque (Nm)	11.08	11.16	11.11	11.12	0.04	reference
28 mm	Torque (Nm)	10.15	10.78	10.75	10.56	0.36	−5.01%
30 mm	Torque (Nm)	10.92	10.88	10.13	10.64	0.45	−4.26%

The 30 mm throttle body produced the highest mean peak power (11.32 HP), marginally above the 26 mm standard unit (11.25 HP), while the 28 mm unit produced the lowest peak power. For torque, the 26 mm standard throttle body produced the highest mean peak value (11.12 Nm) with the smallest standard deviation among all groups, indicating the most repeatable output. Notably, the power ranges of the 26 mm and 30 mm groups (11.25 ± 0.15 HP versus 11.32 ± 0.34 HP) overlap substantially, suggesting the difference may not be statistically meaningful—a possibility examined formally below.

Homogeneity of Variance (Levene's Test)

Table 5. Test of Homogeneity of Variances

Parameter	**Basis**	**F**	**df1**	**df2**	**Sig.**
Power (HP)	Mean	5.251	2	6	0.048
Power (HP)	Median	0.444	2	6	0.661

Power (HP)	Median (adj. df)	0.444	2	2.606	0.682
Power (HP)	Trimmed mean	4.379	2	6	0.067
Torque (Nm)	Mean	6.600	2	6	0.031
Torque (Nm)	Median	0.473	2	6	0.644
Torque (Nm)	Median (adj. df)	0.473	2	3.835	0.655
Torque (Nm)	Trimmed mean	5.305	2	6	0.047

The mean-based Levene test yielded significant results for both power (Sig. = 0.048) and torque (Sig. = 0.031), suggesting unequal variances across groups—consistent with the comparatively larger standard deviations observed for the 30 mm throttle body (SD = 0.34 for power, 0.45 for torque) relative to the 26 mm unit (SD = 0.15 and 0.04, respectively). However, the more robust median-based (Brown–Forsythe-type) test showed non-significant results for both parameters (Sig. = 0.661 and 0.644), and the balanced design (n = 3 in every group) is known to make the ANOVA F-test reasonably robust to moderate variance heterogeneity. The ANOVA results below are therefore still reported, with this caveat duly noted.

One-Way ANOVA

Table 6. Descriptive Statistics by Group

Parameter	TB	N	Mean	SD	Min	Max
Power (HP)	26 mm	3	11.250	0.151	11.08	11.37
Power (HP)	28 mm	3	10.810	0.085	10.73	10.90
Power (HP)	30 mm	3	11.323	0.341	10.93	11.54
Torque (Nm)	26 mm	3	11.117	0.040	11.08	11.16
Torque (Nm)	28 mm	3	10.560	0.355	10.15	10.78
Torque (Nm)	30 mm	3	10.643	0.445	10.13	10.92

Table 7. One-Way ANOVA – Power (HP)

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.462	2	0.231	4.731	0.058
Within Groups	0.293	6	0.049		
Total	0.756	8			

Table 8. One-Way ANOVA – Torque (Nm)

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.541	2	0.270	2.489	0.163
Within Groups	0.652	6	0.109		
Total	1.193	8			

For power, ANOVA yielded F(2,6) = 4.731, Sig. = 0.058, which is above the 0.05 threshold; H1 is therefore not supported, although the result is close to marginal significance. The associated effect size (η^2 = 0.612, obtained from a General Linear Model univariate analysis in SPSS) indicates that throttle body diameter accounted for approximately 61.2% of the observed variance in power—a large effect that nonetheless did not reach significance given the small per-group sample size (n = 3). For torque, ANOVA yielded F(2,6) = 2.489, Sig. = 0.163; H2 is likewise not supported, with an effect size of η^2 = 0.453, again a substantial but statistically inconclusive effect.

Post-Hoc Tukey HSD Test

Table 9. Multiple Comparisons (Tukey HSD) – Power (HP)

(I) TB	(J) TB	Mean Difference (I−J)	Sig.
26 mm	28 mm	0.440	0.111
26 mm	30 mm	−0.073	0.914
28 mm	30 mm	−0.513	0.066

Table 10. Multiple Comparisons (Tukey HSD) – Torque (Nm)

(I) TB	(J) TB	Mean Difference (I−J)	Sig.
26 mm	28 mm	0.557	0.177
26 mm	30 mm	0.473	0.261
28 mm	30 mm	−0.083	0.949

All pairwise comparisons exceeded the 0.05 significance threshold, corroborating the omnibus ANOVA result that no pair of throttle body diameters differs significantly. The comparison closest to significance was 28 mm versus 30 mm for power (Sig. = 0.066), consistent with this pair showing the largest observed mean difference in Table 4.

DISCUSSION

Power Response to Throttle Body Diameter

The descriptive gain in peak power for the 30 mm throttle body (11.32 HP) over the 26 mm standard (11.25 HP) amounts to only 0.65%, and ANOVA confirms this difference is not statistically significant (p = 0.058). This result diverges from Laksono (2025), who reported that a 32 mm racing throttle body produced clearly higher power and torque than 26 mm and 28 mm units on the same Vario 150 cc platform, and from Prasetyo et al. (2023), who found a 30 mm bore delivering the highest power on a comparable 149 cc engine. The discrepancy is most plausibly explained by ECU calibration: both Laksono (2025) and Fauzil et al. (2023) worked with, or explicitly identified the benefit of, recalibrated or racing ECUs, whereas the present study retained the fully standard fuel map. This is consistent with Maulana et al. (2023), who found that a 32 mm throttle body under a standard ECU raised power only marginally (1–5%) while reducing torque, precisely the asymmetric pattern also observed here. Taken together, these comparisons support the interpretation that bore enlargement primarily raises the theoretical airflow ceiling (Laksono, 2025), but realising that ceiling as usable power requires the ECU to extend injector pulse width accordingly—a capability a factory fuel map is not designed to provide.

Torque Response to Throttle Body Diameter

Torque followed the opposite pattern: the 26 mm standard throttle body produced the highest and most repeatable mean torque (11.12 ± 0.04 Nm), while both larger bores produced lower, more variable torque (28 mm: 10.56 ± 0.36 Nm; 30 mm: 10.64 ± 0.45 Nm), though again without statistical significance ($p = 0.163$). This mirrors Lapisa et al. (2022), who found that an intermediate 24 mm bore—rather than the largest tested diameter—produced the best torque on a 110 cc engine, illustrating that torque is more sensitive than power to a mismatch between bore size and intake air velocity at moderate engine speed. Faerus and Pohan (2022) similarly found that intake-geometry changes shifted torque and power characteristics without uniformly improving both, and Nindito et al. (2023) reported that a racing throttle body raised power and torque on a Honda CB150R only at the cost of increased fuel consumption, implying the mixture was enriched to compensate for the larger bore—an adjustment the standard ECU in the present study could not replicate. Candra Putra et al. (2021) additionally noted that torque rises faster than power at low-to-mid engine speed across small-displacement engines, which helps explain why the throttle-body effect in this study was more consequential for the early-to-mid rev range (where torque peaks) than for the high-rev range (where power peaks).

Rev-Range Characteristics and Practical Implications

Beyond peak values, the rev-range curves (Figures 1 and 2) reveal a practically meaningful pattern that a peak-value comparison alone would miss: the 30 mm throttle body sustained power above 11 HP from 7,500 to 8,500 rpm, a broader effective band than the 26 mm and 28 mm units, which declined more sharply after their respective peaks. This is consistent with Almeyda and Firdaus (2024), who linked shorter, less restrictive intake paths to sustained high-rpm airflow and power retention. Kamaludin (2026) likewise found that throttle body and ECU variation jointly reshaped the AFR, MEP, and BMEP profile across the rev range rather than shifting a single peak value, reinforcing that the appropriate throttle body choice depends on the intended operating range: the 26 mm standard unit suits everyday, low-to-mid rpm urban riding, whereas the 30 mm unit may benefit riders who sustain higher engine speeds, provided ECU recalibration accompanies the hardware change.

Statistical Considerations

The absence of statistical significance despite a descriptively large effect size ($\eta^2 = 0.612$ for power; 0.453 for torque) is attributable primarily to the small number of replications ($n = 3$ per group), which limits statistical power. Azhar

(2023) and Hifni et al. (2025), by contrast, reported statistically clearer performance differences when comparing fundamentally different fuel-delivery systems (carburettor versus injection) rather than incremental bore-diameter changes within an already-injected platform, suggesting that the magnitude of intervention—not only sample size—affects the likelihood of reaching significance. This points directly to the recommendation, detailed below, that future replication of this design should increase the number of test repetitions.

CONCLUSIONS AND RECOMMENDATIONS

Variation in throttle body diameter (26, 28, and 30 mm) produced descriptive differences in peak power and torque on the standard Honda Vario 150 cc: the 30 mm throttle body yielded the highest mean peak power (11.32 HP), followed by the 26 mm standard unit (11.25 HP) and the 28 mm unit (10.81 HP), while the 26 mm standard unit yielded the highest mean peak torque (11.12 Nm), ahead of the 30 mm (10.64 Nm) and 28 mm (10.56 Nm) units. One-way ANOVA indicated that these differences were not statistically significant at $\alpha = 0.05$ for either power ($p = 0.058$) or torque ($p = 0.163$), and all pairwise Tukey HSD comparisons likewise exceeded 0.05. The standard 26 mm throttle body therefore delivered the most consistent overall performance (smallest standard deviations), while the 30 mm unit showed a tendency to sustain power at higher engine speeds without a statistically confirmed advantage in peak values. These findings indicate that, on a factory-standard ECU, enlarging the throttle body diameter up to 30 mm does not by itself yield a statistically reliable performance improvement; any such modification should be paired with engine-management recalibration (e.g., ECU remapping) to convert the additional theoretical airflow into a realised gain in power and torque.

FURTHER STUDY

This study is limited by its reliance on $n = 3$ replications per configuration and by testing only the factory-standard ECU. Future research should (a) increase the number of replications to strengthen statistical power; (b) combine throttle body diameter variation with ECU remapping, injector capacity change, intake-manifold length variation, or exhaust-system modification to assess interaction effects more comprehensively; and (c) incorporate additional parameters—air-fuel ratio, brake-specific fuel consumption, volumetric efficiency, and exhaust emissions—to provide a more complete picture of how throttle body modification affects overall engine behaviour.

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